WATER RESOURCES IN FLUVANNA COUNTY:

Present Conditions and Recommendations for Preservation and Restoration

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Prepared for Fluvanna County
by the
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Summary Findings and Recommendations

The funding available to complete the 604(b) Fluvanna County Water Quality Management Plan was sufficient for Phase One of the project to be fully completed. Phase Two work, completed by Timmons for the engineering portion of the study, was funded by Fluvanna County. The study is completed in two documents: *Timmons, Water and Wastewater Preliminary Engineering Report and Facilities Master Plan,* and this document *Water Resources in Fluvanna County.* Both documents are being presented to the Fluvanna County Board of Supervisors to assist them in decision-making for future water and waste water projects. Each portion of the study is complete in itself, though the two documents complement each other with different aspects of water quality management being explored.

Groundwater is the major current source of drinking water for the county residents and it is important to understand the limits of this resource as well as limitations to its use and actions that can be taken to protect the groundwater resource. Given the rural nature of Fluvanna County and the commitment of the Board of Supervisors to maintaining a rural character, the staff believes it is important to protect this resource, particularly in areas not feasible to be served with public water supplies.

Additional information is included in this document relative to water quality. The TJPDC has been involved with an analysis of conditions in the Rivanna River Basin and published a 604(b) funded report entitled *State of the Rivanna River Basin, 1998.* This study has been presented to the Board of Supervisors, the Planning Commission, and various civic groups in the County. The study provided a great deal of information about water quality in the Rivanna River, which is used in this document. The study also found a great deal of information that was not available and the call for data development is repeated here to reinforce the need for adequate data for decision making and protection of the water. This takes on additional importance as Fluvanna County considers using the Rivanna for a drinking water source.

As a result of work conducted in preparing data for this report, the Fluvanna County Health Department now has a computerized hydrogeologic database on which to build. Maintaining an on-going information bank will be useful to the County in future water and wastewater planning. This layer of information will be compatible to most Geographic Information Systems available to the County in the future as well.

The limitations of the project suggest additional studies to be undertaken or completed as time and resources permit. Several of the suggested activities could be accomplished by state agencies and their coordination of information development and recording of same.

Findings:

Water Quality

In good weather, the water quality in the streams in Fluvanna is good. However, in high flows due to storms, the water quality is lowered by high levels of phosphorus, total suspended solids, and fecal coliform. Phosphorus and total suspended solids threaten aquatic life. Fecal coliform is a human health hazard. In more detail, the findings are:

- Several stations along the Rivanna have readings of pH lower than the 6.5-8.5 range for drinking water; the Hardware River readings are sometimes well above this range. However, mean readings all fall within the standard. pH is important for fish habitat, shad preferring the lower range. High readings could be from contamination and cause corrosion and release of metals from plumbing pipes.

- No low measurements of dissolved oxygen or high measurements of ammonia/ammonium concentration, nitrate and nitrite concentrations were found.

- Phosphorus concentrations have exceed DEQ standards at all test sites during storm flow. This is of concern and should be addressed due to the possibility of algal blooms and eutrophication. Eutrophication is the overgrowth of plants which lowers the dissolved oxygen levels, making it less habitable to fish and animal life. Sources include agricultural and urban land uses as well as sewage treatment plant discharge.

- All stations exceeded the maximum fecal coliform level during storm flows. While many sources are possible, they are not known at this time.

- The two Rivanna stations recorded high turbidity, or particles in the water, which has a negative effect on plants and filter feeders, such as mussels. Storm flow readings of Total Suspended Solids all also exceeded recommended limits recommended for shad; three stations exceeded limits for *all* fish.

- Acid groundwater and fecal coliform contamination of groundwater are likely widespread problems throughout the County, based on information from the volunteer testing program.

- All major watersheds in Fluvanna have, on average, adequate forest cover as identified through the Virginia Gap Analysis Project. Forests are the best cleansers of surface water runoff.

- None of the watersheds contain significant percentages of disturbed land; most of the developed land is around Lake Monticello.

- The amount of impervious surface in the area around Lake Monticello causes the area to be at risk for degradation of the water from runoff.

- Eight Class 1 watersheds were designated High Priority due to nutrient loading and/or amounts of wetlands and/or presence of Natural Heritage listed species.

- A significant number of abandoned mining sites are located in the County which could cause water quality problems in the future.

Groundwater

Groundwater availability and vulnerability to contamination is determined by factors related to soils, saprolite (weathered rock), and bedrock geology.

- In general, the western portion of Fluvanna County is less favorable in terms of groundwater productivity than the rest of the County

- Underlying bedrock types in the Bremo Bluff-Fork Union-Columbia area and northeast of Palmyra are the most productive types of bedrock in terms of groundwater productivity. These areas may contain open fractures with substantial groundwater reserves at depths of 1,000 feet or more.

- On average, there is ample thickness of saprolite in Fluvanna County for purposes of groundwater storage and sanitary drain field siting. Given variations of soils, rock, and saprolite, consideration of each site may yield different answers to groundwater availability and vulnerability, and drain field capacity.

- Groundwater recharge areas are best protected by mature forest land cover.

Recommendations

Incorporate the following goals in the Comprehensive Plan currently being developed for Fluvanna County:

1. Protect and maintain the water quality of Fluvanna County' streams and rivers;
2. Protect and maintain the water quality in Fluvanna County' groundwater supply areas; and
3. Protect and maintain the water quality in present and future Fluvanna county impoundments.

Develop a water resources protection plan for Fluvanna County which addresses use of stream buffers, control of storm water, creation of protection zones for wells and surface water, and other specific items put forth in Chapter 3 of this report, which is ultimately incorporated into the Comprehensive Plan.

Explore the development of a geologic/soils based zoning and development program.

Establish a working relationship with state and local monitoring agencies to ensure that monitoring is coordinated, reported to a centralized, accessible data base, with an emphasis on testing for fecal coliforms, contamination from old mine sites, pH, phosphorus, and total suspended solids, identifying sources as specifically as possible.

Establish a groundwater hydrogeologic testing program to ascertain the effects of new wells on existing wells. This is particularly important when approving new subdivisions which will be dependent on groundwater. Incorporate data from all hydrogeologic tests performed in the County into the hydrogeologic database.

Establish a County-wide geographic information system (GIS) which will incorporate the mapping products of this study.   Build on this system by acquiring digital soils maps, and developing water quality and other spatial data layers.

Require that new wells be precisely located, using Global Positioning System (GPS) and, that "dry holes" drilled in the process of locating groundwater be located with GPS and reported to the Health Department.

Work with upstream localities to insure the quality of the water flowing through Fluvanna County.

Perform additional testing to ascertain the sources of fecal coliforms, particularly at the Leslie site.

Incorporate citizen education and participation processes in implementing this study.

1.0 PRESENT WATER QUALITY AND THREATS TO WATER QUALITY IN FLUVANNA COUNTY

The water resources in Fluvanna County include rivers, creeks, impoundments (lakes), and groundwater supplies. These resources provide drinking water, recreation and aesthetic value for the citizens of the County, and habitat for many species indigenous to the Piedmont. To determine how well the water resources currently support these uses, and what some of the near-term threats might be, a review of previous studies and available water quality data was undertaken. A summary of the findings is presented here.

1.1 Watersheds - General Description

Fluvanna County contains 282 square miles, of which 99.8% drains to the James River or one of its tributaries. The remaining 0.2% is in two small areas in the northern section of the County (Figure 1-1). These drain to tributaries of the South Anna River, which is part of the York River watershed. All of Fluvanna County is in the Chesapeake Bay watershed.

<u>1.1.1 Rivanna River</u>

Just over half (51.2%) of the County is in the watershed of the Rivanna River, which joins the James River in Fluvanna at Columbia. The Rivanna River has its headwaters primarily in western Albemarle and southern Greene Counties, then flows through the City of Charlottesville and eastern Albemarle before entering Fluvanna County in the northwest. It skirts the 10,000-lot Lake Monticello subdivision before passing by Palmyra, the county seat, in the center of the County and winding its way to Columbia in the southeast corner. The largest hydrologic unit (watershed) in the Rivanna basin in Fluvanna is H31, Lower Rivanna River/Buck Island Creek, which covers 32% of the County, including Lake Monticello, Palmyra, part of Columbia, and most of Fork Union (which straddles the boundary with the James River/Bear Garden Creek/South Creek watershed).

<u>1.1.2 James and Hardware Rivers</u>

The James River forms the southern boundary of Fluvanna, and the lower 30% of the County drains directly to the James, one of its minor tributaries, or the Hardware River. The Hardware River originates in southern Albemarle County and drains about 9% of the southwest portion of Fluvanna County. No major towns are located along its length. The Hardware River State Wildlife Management Area is located along its banks near the confluence with the James.

The James River watershed covers about a third of the Chesapeake Bay drainage area in Virginia. It is entirely contained in Virginia, and its boundary forms part of the western boundary of Virginia. The James itself is formed at the confluence of the Cowpasture and Jackson Rivers in Botetourt County in western Virginia. It then flows from the foothills of the

Allegheny Mountains through the Blue Ridge Mountains, past the City of Lynchburg, and northeast between Amherst and Appomattox, Nelson and Buckingham, and Albemarle and Buckingham Counties before separating Fluvanna from Buckingham and Cumberland Counties. The largest town that the James passes by in Fluvanna is the Town of Scottsville, which straddles the Albemarle/Fluvanna border. State Route 6 runs along the northern border of that part of the watershed within Fluvanna that drains directly to the James or a minor tributary, and is where most of the limited development in that area is located. The James passes the Bremo Bluff power station about midway across the County, and leaves Fluvanna County at its junction with the Rivanna River at Columbia.

1.1.3 Byrd Creek

Nineteen percent of Fluvanna County drains to Byrd Creek, which joins the James River in Goochland County. The Byrd Creek watershed covers most of the northeast corner of Fluvanna. It includes some small villages, the largest being Kents Store, but no major development.

1.2 Present and Historical Water Quality

1.2.1 Surface Water

There are two sources for surface water quality data in Fluvanna County: the Virginia Department of Environmental Quality, and the Rivanna River Basin Project. The DEQ data has the advantage of covering a longer time period, and of covering areas outside of the Rivanna River Basin. However, the Rivanna River Basin Project data, where available, has the advantage that samples were timed with respect to storm events. One sample was taken at each station during each season during base flow and during storm flow, so that differences in pollutant levels during the two types of flow could be compared. DEQ samples are spaced fairly evenly but not timed with regard to storm events. Examination of the historical record of DEQ sites with respect to flow recorded at USGS gauging stations has generally found that high pollutant levels occurred during high flow levels. This is most likely the result of runoff during storm events (for more on this, see section 1.3.1).

1.2.1.1 Department of Environmental Quality Data

There are six DEQ stations within Fluvanna County. A station on Byrd Creek in Goochland County was also examined, as a substantial portion of Fluvanna drains to Byrd Creek and there is no station on Byrd Creek in Fluvanna. Station locations are shown on Figure 1-1 and described in the table below. For all stations except Byrd Creek, the data reporting period is from late August 1992 to Spring 1997 (varies from late April to mid-June). For Byrd Creek, the reporting period is from August 1994 to December 1998.

Station	Watershed
Rivanna River upstream of Rt. 15 bridge	H31 - Lower Rivanna River/Ballinger Creek
Rivanna River upstream of Rt. 6 bridge at Columbia	H31 - Lower Rivanna River/Ballinger Creek
Mechunk Creek at Rt. 616 bridge	H30 - Mechunk Creek
Cunningham Creek at Rt. 660 bridge	H32 - Cunningham Creek
Hardware River at Rt. 637 bridge	H19 - Hardware River
James River 0.2 miles downstream of Rt. 20 bridge	H17 - James River/Totier Creek/Rock Island Creek
Byrd Creek at Rt. 603 bridge (Goochland Co.)	H34 - Byrd Creek

The DEQ data was examined for pH, dissolved oxygen, nitrogen and phosphorus concentrations, fecal coliform counts, and turbidity. Each of these parameters has important implications for habitat, human use, or both, as discussed in the section for that measure.

pH: Virginia Water Quality Standards call for pH in nontidal waters to range between 6 - 9 (7 being neutral; < 7 is acid, and > 7 alkaline). Shad, which will be able to reach Fluvanna's waters once the Bosher's Dam fish passage on the James River in Richmond is complete (projected for 1999), have a narrower pH tolerance of 6 - 7.5 (Living Resources Subcommittee, Chesapeake Bay Program). A pH range between 6.5 - 8.5 is recommended for drinking water. Excessive acidity may cause corrosion in pipes and cause toxic metals from the plumbing to be released into the drinking water. Water with a pH above 8.5 is usually not found naturally and may be an indication of contamination. High pH greatly increases the toxicity of ammonia. The pH results in the table on page 5 are from *in situ* measurements.

Station	Mean pH	Minimum pH	Maximum pH
Rivanna River/Rt. 15	7.41	**5.10**	8.90
Rivanna River/Columbia	7.44	**5.62**	8.80
Mechunk Creek	7.30	**5.73**	8.50
Cunningham Creek	7.10	**5.33**	7.90
Hardware River	7.48	6.00	**9.60**
James River	7.60	6.20	8.50
Byrd Creek	6.75	6.44	7.08

Bold - falls outside of Virginia Water Quality Standard of 6.0 - 9.0

No station has a pH average falling outside of Virginia Water Quality Standards or the range recommended for drinking water. However, all four of the DEQ stations within the Rivanna Basin (the first four listed) have had incidences of pH below the VA WQS, and the Hardware River has had pH measured at well above the WQS. All of the other stations, with the exception of Cunningham Creek, have had pH measurements at 8.5 or above. With respect to the tolerance of shad, all stations have had incidences of pH above or below their range, but have an average pH within it, with the exception of the James River station. The average pH at the James River station is 0.10 above the range for shad, a concern for the return of these once-abundant migratory fish. Causes of low pH can be acid deposition/acid rain, acid mine drainage, or industrial pollution; in this case, the first is the most likely. Causes of high pH are usually industrial; further study should be undertaken with respect to the high pH reading for the Hardware River.

Dissolved Oxygen: DEQ's measurements of dissolved oxygen, critical to most aquatic species, indicate that the rivers and streams of Fluvanna are in good shape with respect to this important constituent. Virginia Water Quality Standards call for an average dissolved oxygen measurement of 5.0 mg/L, and a minimum of 4.0 mg/L, in nontidal waters. The lowest average found was 9.6 mg/L, and the lowest measure found was 6.2 mg/L, both in Byrd Creek. These exceed even the most stringent Virginia standards, those for natural trout waters (7.0 mg/L and 6.0 mg/L for the mean and low respectively).

Nitrogen: Inorganic nitrogen is found in natural waters in three forms: nitrate (NO_3), nitrite (NO_2), and ammonia/ammonium (NH_3/NH_4^+). Nitrate and ammonium are the two forms most readily accessible to plants; an excess of these may result in an algal bloom, but usually phosphorus is the limiting nutrient in freshwater (however, nitrogen is often the limiting nutrient in estuaries such as the Chesapeake Bay). High levels of nitrate or nitrite may cause methemoglobinemia (blue baby syndrome), which is potentially fatal. Virginia Water Quality Standards allow for a maximum nitrate nitrogen concentration of 10 mg/L. Virginia does not have a WQS for nitrite nitrogen, but the U.S. EPA has an MCL (Maximum Contaminant Level) of 1 mg/L. Ammonia is toxic at high concentrations, but toxicity varies with pH and temperature. Virginia Water Quality Standards for ammonia in freshwater vary from 35 mg/L (pH 6.5, 0ºC) to 0.83 mg/L (pH 9, 10ºC) for acute conditions, and 3.02 mg/L (pH 6.5, 0ºC) to 0.19 mg/L (pH 9, 10ºC) for chronic conditions. Ammonia/ammonium concentrations as measured by the DEQ in Fluvanna have never exceeded even the lowest of these concentrations: the highest NH_3/NH_4^+ concentration measured in Fluvanna County was 0.14 mg/L, in the James River. Nitrate concentrations have not exceeded the VA WQS of 10 mg/L; the highest nitrate concentration found was 2.16 mg/L, at the Rt. 15 station on the Rivanna River. Next highest was the Rivanna River at Columbia, with 1.06 mg/L of nitrate. The highest mean nitrate concentration found was 0.656 mg/L at the Rt. 15 station. Nitrite concentrations have been considerably lower than the EPA MCL of 1.0 mg/L; the highest nitrite concentration found was 0.08 mg/L, on the Rivanna at Columbia. Mean nitrite concentrations were 0.01 - 0.02 mg/L at all stations.

Phosphorus: As mentioned above, phosphorus is usually the limiting nutrient for plants in freshwater systems. Therefore, elevated levels of phosphorus can result in algal blooms and eutrophication (the overgrowth of plant life at the expense of dissolved oxygen, and therefore, animal life). DEQ has set an advisory standard enrichment trigger for phosphorus of 0.2 mg/L. The U.S. EPA goes even further, and suggests that to control algal blooms, phosphorus concentrations should not exceed 0.1 mg/L for streams and rivers, 0.05 for streams entering lakes, and 0.025 for lakes and reservoirs.

Station	Mean Phosphorus Concentration (mg/L)	Maximum Phosphorus Concentration (mg/L)
Rivanna River/Rt. 15	0.145	**0.500**
Rivanna River/Columbia	0.135	**0.400**
Mechunk Creek	0.126	**0.600**
Cunningham Creek	0.126	**0.600**
Hardware River	0.193	**0.500**
James River	0.133	**0.300**

Bold - exceeds Virginia DEQ advisory standard of 0.2 mg/L

As seen in the table above, maximum phosphorus concentrations have exceeded the DEQ advisory standard at all stations. In the Hardware River, even the mean concentration is close to the advisory standard. Mean concentrations exceed the EPA's water quality criteria for streams and rivers at all stations. Phosphorus concentrations are clearly of concern in Fluvanna County, and should be addressed. Sources include runoff from both agricultural and urban land uses and sewage treatment plant discharge.

Fecal Coliforms: Fecal coliforms, bacteria found in the digestive systems and wastes of warm-blooded animals, are not necessarily harmful. However, they indicate the possible presence of pathogenic, or disease-causing, organisms. The Virginia Water Quality Standards call for fecal coliform concentrations not exceeding a geometric mean of 200 cells/100 mL of water for two or more samples over a 30-day period, or 1000 cells/100 mL at any time.

Station	**Mean Fecal Coliform Count (cells/100 mL)**	**Maximum Fecal Coliform Count (cells/100 mL)**
Rivanna River/Rt. 15	502	**5,100**
Rivanna River/Columbia	533	**4,300**
Mechunk Creek	150	1,000
Cunningham Creek	253	**1,700**
Hardware River	786	**8,000**
James River	437	**8,000**
Byrd Creek	867	**9,200**

Bold - exceeds Virginia Water Quality Standard of 1000 cells/100 mL

All of the stations have exceeded the maximum set forth by DEQ, except for Mechunk Creek which just meets it. Although the samples were not generally taken within the same month, it seems likely that most of these stations (with the possible exception of Mechunk Creek) would also exceed the 200 cell/mL mean 30-day standard, if tested for it. Fecal coliform contamination appears to be a problem in much of Fluvanna County. Sources may include livestock, septic tank failure, sewage system leaks, pet wastes, and wildlife. Because it would be impossible to treat all possible sources of fecal coliform contamination, it is important, although expensive, to determine the source(s) through genetic testing of the bacteria. This will determine the next steps to correct the problem.

Turbidity: Turbidity is a measure of the suspended particles in the water, both organic and inorganic. It is measured by the degree of scattering of light by the particles. Until mid-1994, DEQ measured turbidity in the field; staff then switched to using a laboratory turbidimeter. Before the switch, turbidity was measured in NTU (nephelometric turbidity units), and after, in FTU (formazin turbidity units); fortunately for our purposes, 1 FTU = 1 NTU. High turbidity is often the result of suspended sediment. It results in a decrease in light penetration, which in turn can result in a decrease in photosynthetic activity and in a decrease in the invertebrates and vertebrates dependent on phytoplankton, algae and plants. Large amounts of suspended sediment can also clog the feeding mechanisms of filter feeders, such as mussels. As the sediment settles out of the water, habitat is degraded for many invertebrates, such as mayfly and caddisfly larvae, and spawning areas are reduced for fish such as chub, which require clear gravel and rocks for successful reproduction. Virginia does not have a turbidity standard. However, Harvey (*Technical Review of Sediment Criteria, for Consideration for Inclusion in Idaho Water Quality Standards*. Idaho Dept. of Health and Welfare, 1989) recommends a limit of 50 NTU instantaneously, or 25 NTU for a 10-day average. A limit of 25 NTU is also called for by the North Carolina code.

Station	Mean Turbidity (NTU/FTU)	Maximum Turbidity (NTU/FTU)
Rivanna River/Rt. 15	(7/92 - 6/94) 37.1 (7/94 - 6/97) 16.9	(7/92 - 6/94) **280.0** (7/94 - 6/97) **93.0**
Rivanna River/Columbia	(7/92 - 6/94) 39.6 (7/94 - 5/97) 18.9	(7/92 - 6/94) **240.0** (7/94 - 5/97) **116.0**
Mechunk Creek	(7/92 - 6/94) 6.5 (8/94 - 4/97) 6.1	(7/92 - 6/94) 11.6 (8/94 - 4/97) 17.4
Cunningham Creek	(7/92 - 6/94) 5.0 (8/94 - 4/97) 5.1	(7/92 - 6/94) 12.0 (8/94 - 4/97) 7.3
Hardware River	(7/92 - 6/94) 30.1 (8/94 - 6/97) 24.1	(7/92 - 6/94) **230.0** (8/94 - 6/97) **245.0**
James River	(7/92 - 6/94) 7.7 (8/94 - 6/97)12.6	(7/92 - 6/94) 40.0 (8/94 - 6/97) **156.0**
Byrd Creek	(7/94 - 10/98) 7.5	(7/94 - 10/98) 20.0

Bold - exceeds maximum recommended for Idaho Water Quality Standard (no VA standard)

In comparison with the standard of 25 NTU, Mechunk Creek, Cunningham Creek, and Byrd Creek are clearly in good shape. The James River is fine on average, but has had an instantaneous measurement over three times the 50 NTU standard. The two Rivanna stations and the Hardware River station averaged more than 25 NTU when turbidity was being measured *in situ*, but measurements with the laboratory turbidimeter are lower. High measurements for all three stations remain greater than 50 NTU for the newer method, although both Rivanna stations have not had as high readings. The Hardware River, on the other hand, has had a measurement of 245 NTU with the newer equipment, nearly five times the 50 NTU standard. Further study is needed of turbidity in the Hardware, Rivanna, and James Rivers to be certain of its components and source, but it appears that these rivers may have a sedimentation problem. Major sources of sediment include unvegetated streambanks, cropland erosion, and construction sites.

1.2.1.2 Rivanna River Basin Project Data

Concern for the fate of the Rivanna River in its rapidly urbanizing environment led to the establishment of the Rivanna River Basin Project by the Thomas Jefferson Planning District Commission. Funding for the project was provided by an EPA 604(b) grant. Thousands of hours of volunteer labor were donated by citizens who served in either of two long-term capacities. Field teams gathered water quality data beginning in November 1996 under the direction of the Environmental Education Center. The Rivanna River Basin Roundtable, made up of 24 volunteers from around the watershed and all walks of life, analyzed that and other data and made recommendations for the safeguarding of the river for the future in its report, *State of the Basin: 1998*. Macroinvertebrate sampling is ongoing, and the Roundtable is expected to reconvene in an expanded format and begin working on recommendation implementation in 1999.

The Rivanna River Basin Project has five stations in Fluvanna County. Three of these have approximately the same locations as the DEQ stations, one (on Cunningham Creek) is downstream, and one, at the base of H29 (the Middle Rivanna River/Buck Island Creek watershed), is unique to the RRBP. Station locations are shown in Figure 1-1, and described in the table below.

Station	Watershed
Rivanna River on the Leslie property, 3/4 mile upstream of the confluence with Mechunk Creek	H29 - Middle Rivanna River/Buck Island Creek
Rivanna River upstream of Rt. 15 bridge	H31 - Lower Rivanna River/Ballinger Creek
Rivanna River upstream of Rt. 6 bridge at Columbia	H31 - Lower Rivanna River/Ballinger Creek
Mechunk Creek at Rt. 616 bridge	H30 - Mechunk Creek
Cunningham Creek at Rt. 15 bridge	H32 - Cunningham Creek

The Rivanna River Basin Project took samples for total nitrogen, total phosphorus, fecal coliforms, and total suspended solids. In addition, the Izaak Walton League's SOS (Save Our Streams) methodology was used to evaluate benthic macroinvertebrate diversity. Water chemistry samples were taken twice per season, once during base flow and once during storm flow. Benthic macroinvertebrates were examined once per season, or as often as weather and volunteer availability permitted.

<u>pH:</u> The RRBP data indicate that the acidic (<7) pH levels seen in the DEQ data are probably occurring during stormflow. However, the pH extremes found in the RRBP samples are considerably more moderate than those in the DEQ data. No RRBP station had a pH measurement above 7.5 or below 6.0. Although RRBP data do not indicate a pH problem in the Rivanna Basin in Fluvanna, the DEQ data indicate that pH should continue to be monitored.

Station	Mean pH		Minimum pH		Maximum pH	
	Base	Storm	Base	Storm	Base	Storm
Rivanna River/Leslie site	7.38	6.93	7.26	6.75	7.46	7.03
Rivanna River/Rt. 15	7.21	6.93	7.10	6.66	7.32	7.05
Rivanna River/Columbia	7.19	6.86	7.18	6.56	7.20	7.02
Mechunk Creek	7.27	7.02	7.18	6.77	7.37	7.23
Cunningham Creek	7.22	6.85	7.15	6.24	7.21	7.27

<u>Nitrogen:</u> The RRBP monitored only total nitrogen, for which DEQ has not set a standard. Clearly, no violations of the Virginia Water Quality Standard for nitrate (10 mg/L) have occurred, but whether violations of the EPA MCL for nitrite of 1 mg/L occurred is more difficult to assess (it seems unlikely, however, in light of the measurements obtained by DEQ). The Rivanna station at Columbia exceeded 1 mg/L total nitrogen on average during base flow, three stations exceeded it on average during storm flow, and all stations exceeded it at least once during both base and storm flow. Measurement of nitrite as a separate component would be necessary to be absolutely certain. As pH levels measured during all sampling events were relatively moderate (with corresponding chronic standards for ammonia of 2.5 - 3.02 mg/L), it does not appear that ammonia standards were violated

Station	Mean Total Nitrogen Concentration (mg/L)		Maximum Total Nitrogen Concentration (mg/L)	
	Base	Storm	Base	Storm
Rivanna River/Leslie site	0.950	1.275	1.400	1.515
Rivanna River/Rt. 15	0.879	1.321	1.446	1.994
Rivanna River/Columbia	1.026	1.439	2.185	2.487
Mechunk Creek	0.733	0.893	1.441	1.246
Cunningham Creek	0.944	0.736	2.062	1.378

<u>Phosphorus:</u> As with pH, the RRBP data for phosphorus shows a clear effect of stormwater runoff. No stations exceeded the DEQ advisory standard for enrichment of 0.2 mg/L at any time during base flow (although the two more upstream Rivanna stations did, on average, exceed the EPA advisory standard for controlling algal bloom of 0.1 mg/L). However, all stations exceeded the DEQ advisory standard for phosphorus at least once during storm flow, and the three Rivanna stations were double it or nearly double it on average (Mechunk and Cunningham Creeks

remained well below the DEQ advisory standard on average, although concentrations in Cunningham Creek equaled the EPA advisory standard). Elevated phosphorus levels during storm flow, particularly on the main stem of the Rivanna, are clearly of concern in the Rivanna Basin in Fluvanna County.

Station	**Mean Phosphorus Concentration (mg/L)**		**Maximum Phosphorus Concentration (mg/L)**	
	Base	**Storm**	**Base**	**Storm**
Rivanna River/Leslie site	0.11	**0.36**	0.15	**0.58**
Rivanna River/Rt. 15	0.10	**0.34**	0.12	**0.67**
Rivanna River/Columbia	0.08	**0.40**	0.09	**0.73**
Mechunk Creek	0.02	0.09	0.02	**0.24**
Cunningham Creek	0.02	0.10	0.02	**0.27**

Bold - exceeds Virginia DEQ advisory standard of 0.2 mg/L

<u>Fecal Coliforms:</u> Fecal coliform counts at all RRBP stations were well within Virginia Water Quality Standard limits during base flow. However, maximum measurements during storm flow were, at every site corresponding to a DEQ station, higher than any measurement obtained by DEQ. Fecal coliform counts for one measurement at the Leslie site were **over 100 times** the 1000 cells/100 mL standard. No site averaged less than double the 1000 cells/100 mL standard during storm flow. Fecal coliform concentrations during storm flow are definitely of concern in the Rivanna Basin in Fluvanna County. In particular, more research should be done to determine the reason for the spectacularly high counts at the Leslie site.

Station	**Mean Fecal Coliform Count (cells/100 mL)**		**Maximum Fecal Coliform Count (cells/100 mL)**	
	Base	**Storm**	**Base**	**Storm**
Rivanna River/Leslie site	34	**30,832**	40	**104,000**
Rivanna River/Rt. 15	37	**12,352**	49	**35,000**
Rivanna River/Columbia	32	**5,675**	54	**15,000**
Mechunk Creek	35	**6,823**	74	**24,200**
Cunningham Creek	31	**2,385**	45	**6,000**

Bold - exceeds Virginia Water Quality Standard of 1000 cells/100 mL

Total Suspended Solids: Like turbidity, the concentration of total suspended solids is a measure of the suspended particles in the water column. Total suspended solids, however, are commonly measured by filtering a water sample of known quantity through a pre-weighed filter, then drying the filter and weighing it again. Thus, the units for TSS are mg/L. Despite the difference in methodology, high TSS concentrations have the same implications for the environment as do high turbidity measurements. DEQ has an advisory standard for total dissolved solids (which are those solids passing through a filter) of 500 mg/L, but none for total suspended solids. T.F. Waters, in *Sediment in Streams: Sources, Biological Effects and Control* (American Fisheries Monograph 7, 1995), suggests that the limit for all fish for TSS is 400 mg/L. Shad requirements, according to the Living Resources Subcommittee of the Chesapeake Bay Program, are considerably lower: 100 mg/L. As shown in the table below, base flow concentrations of TSS in the Rivanna Basin in Fluvanna are extremely low. However, all five stations had storm flow concentrations which measured at least once above the level for shad. The three Rivanna mainstem stations exceeded the shad level during storm flow on average, and at their worst, exceeded Waters' suggested maximum for all fish. Although these momentary exceedances have certainly not wiped out all fish in the Rivanna River, nevertheless it is likely that they are putting stress on the fish populations, as well as on the populations of benthic macroinvertebrates.

Station	**Mean Total Suspended Solid Concentration (mg/L)**		**Maximum Total Suspended Solid Concentration (mg/L)**	
	Base	**Storm**	**Base**	**Storm**
Rivanna River/Leslie site	3	216	5	**415**
Rivanna River/Rt. 15	9	229	18	**545**
Rivanna River/Columbia	6	253	9	**560**
Mechunk Creek	2	43	2	117
Cunningham Creek	2	38	3	110

Bold - exceeds suggested (Waters, 1995) limit for TSS for all fish of 400 mg/L

Benthic Macroinvertebrates: Benthic macroinvertebrates are animals without backbones that live in streambeds and can be seen with the naked eye. Some benthic macroinvertebrates have much more stringent requirements about water quality and lack of sedimentation than others, and this is the basis for the SOS water quality methodology. Unlike chemistry measurements which only provide a snapshot in time, the diversity of the benthic macroinvertebrate community is an indicator of the long-term quality of the water and the streambed habitat. In the SOS methodology, points are allotted for each type of animal found, with 3 points for the most sensitive types, 2 for those of moderate sensitivity, and 1 for pollution-tolerant organisms. The sum of the points is the score for the segment. Scoring is as follows:

Poor:	10 or less
Fair:	11 - 16
Good:	17 - 22
Excellent:	>22

Benthic macroinvertebrates have been sampled on 2-6 separate occasions at each of the five RRBP stations (the Columbia site is the only one sampled only twice; all others have been sampled at least four times). All five stations have achieved an excellent score at least once. Cunningham Creek achieved it all four times, but the Rivanna at Rt. 15 and Mechunk Creek both achieved it five out of six times. The two stations at either end of the County – the Leslie site, and the Columbia site – had the most mixed results, with two fair scores, one good score, and one excellent score at the Leslie site, and one fair and one excellent score at the Columbia site. Although benthic macroinvertebrates may be under some pressure in the Rivanna Basin in Fluvanna, so far they are holding up well.

1.2.2 Groundwater

Unfortunately, far more is known about surface water quality than about groundwater quality in Fluvanna County. Although records on well water quality exist at the Virginia Department of Health, the time and effort that would be involved in compiling those records are beyond the scope of this project. Historically, there have been problems with excessive levels of iron and manganese in two of the public wells of the Fork Union Sanitary District (*Fork Union Area Water and Sewer Improvements, Preliminary Engineering Report*, Dewberry & Davis, 1993). More recently, two wells in the FUSD have been removed from service due to contamination, although one is in the process of being brought back on-line (*Water & Wastewater Preliminary Engineering Report and Facilities Master Plan*, Timmons, 1998).

So far, the most comprehensive study of well water that has been made in Fluvanna County is the *Evaluation of Household Water Quality in Fluvanna County, Virginia*, conducted by Virginia Tech in November 1997 (published 1998). In this study, residents of Fluvanna County who used private, individual water supplies, attended a public meeting at which they obtained water sampling kits. The water sampling kits were of two types: one for general water chemistry analysis, and one for bacteriological analysis. Water samples were all collected on the same day at the Virginia Cooperative Extension Office in Palmyra and shipped on ice to Virginia Tech. Participants attended a subsequent meeting to obtain and discuss the test results. Fifty households participated, and 38 raw water samples and 50 tap water samples were tested. The results with respect to water quality standards are shown in the table below.

Test (units)	Standard	Percent of Values Exceeding Standard	
		Raw Water (n=38)	Tap Water (n=50)
Iron (mg/L)	0.3	10.5	14.0
Manganese (mg/L)	0.05	5.2	14.0
Hardness (mg/L)	180.0	5.3	4.0
Sulfate (mg/L)	250.0	0	0
Chloride (mg/L)	250.0	0	0
Fluoride (mg/L)	2 (suggested), 4	0, 0	0, 0
Total Dissolved Solids (mg/L)	500.0	2.6	2.0
pH - Low	6.5	68.4	68.0
pH - High	8.5	0	0
Test (units)	**Standard**	**Percent of Values Exceeding Standard**	
		Raw Water (n=38)	**Tap Water (n=50)**
Saturation Index - Low	-1.0	89.5	92.0
Saturation Index - High	+1.0	0	0
Copper (mg/L)	1 (suggested), 1.3	0, 0	0, 0
Sodium (mg/L)	20.0	0	2.0
Nitrate (mg/L)	10.0	2.6	2.0
Total Coliform	0	50.0	48.0
E. coli	0	23.7	18.0

No households exceeded the standards for sulfate, chloride, fluoride, high pH, high saturation index (meaning that calcium carbonate deposits are likely to form), or copper. Less than 10% exceeded the standards for hardness, total dissolved solids, sodium, and nitrate, and less than 20% exceeded the standards for iron and manganese. However, 68% of households had water with an unacceptably low pH, and about 90% had a low saturation index, meaning that pipe corrosion is likely based on a combination of calcium concentration, total dissolved solids, pH, and alkalinity. About half of the households had coliforms present in their water; about 20% had

E. coli, a type of coliform found in human/animal waste. Since households participating in the study came from all over the County, it appears that acid groundwater and fecal coliform contamination are likely widespread problems throughout the County.

1.3 Threats to Water Quality in Fluvanna County

1.3.1 Land Cover and Impervious Surfaces

In urban and suburban areas, studies have shown that runoff into rivers, streams and lakes increases in direct proportion to the percentage of impervious surface within the drainage sub-basin. Furthermore, studies in more rural areas have shown that agricultural land uses can have similar impacts on runoff as do urban land uses. Regional studies encompassing multiple basins have shown that where impervious surfaces reach ten percent or more of the land area, significant degradation of the ecology of local streams becomes apparent.

Both urban and agricultural areas are renewable resources for runoff of:

- sand, silt, and mud from construction areas and plowed fields
- pesticides and nutrients (phosphates and nitrates, in particular) from lawns, gardens, and croplands
- oil, grease, fuel, and toxic chemicals from automobiles and farm machinery
- viruses and bacteria from animal feces and failing septic systems
- heavy metals from automobile tires, from fertilizers and other diffuse sources

Land cover data available for Fluvanna County is of two types. Virginia Gap Analysis Project coverage, with an emphasis on habitat type but little information on development, is available for the entire county.   A land cover map with detailed development classifications, enabling determination of impervious cover, is available for the Rivanna River watershed. The latter map was developed by the Virginia Department of Mines, Minerals & Energy - Division of Mineral Resources for the Rivanna River Basin Project.

1.3.1.1 Virginia Gap Analysis Project Land Cover

This data (Figure 1-2) was developed through the Virginia Gap Analysis Project by the interpretation of Landsat Thematic Mapper scenes from 1993 and has a pixel resolution of 30m x 30m. It is an Anderson Level I+ map (using a classification system developed by Anderson and others) and includes the following categories:

Deciduous Forest - forested lands containing at least 70% trees that lose their leaves in winter
Coniferous Forest - forested lands containing at least 70% evergreen trees
Mixed Forest - areas with both coniferous and deciduous trees, neither more than 70%
Scrub/Shrubland - woody vegetation less than 3 meters tall; also includes some pasture land
Herbaceous - includes cropland, orchards, vineyards, ornamental horticulture, pasture, fallow fields, rangeland, golf courses, large lawns, recent clear cuts, and other forest openings and

agricultural land
Open Water - any open water area larger than a 30 meter square
Disturbed - includes landfills, bare soil, bare rock, cement, quarries, strip mines, and sandy beaches. Does not necessarily include developed land, which is to be part of the next release (Level II).
Coastal Wetlands - coastal areas not fitting into any of the above areas. Planned to be superseded by the U.S. Fish & Wildlife Service National Wetlands Inventory maps in the Level II release.

Developed land is intended to be represented on the next release of the Virginia Gap Analysis Coverage as DLG roads buffered to 30 meters, but was not included in the current release. A rough approximation was made by TJPDC staff using a DLG road coverage. Three road coverages were available in the PDC's GIS library. The coverage selected for this purpose was the ETAK, Inc. Charlottesville, VA Area road network, dated April 1998 and with positional accuracy conforming to National Map Accuracy standards for 1:100,000 scale maps (160 ft.). This coverage was chosen over the recently-released VDOT county coverage because it was not limited to VDOT-maintained roads, and over the USGS 1:100,000 road coverage because it did not contain trails, dirt roads, or old railroad grades.

Although the categories on this coverage do not break neatly into impervious surface areas, general ranges can be assigned (following the classification scheme used for the DMR coverage, discussed in more detail in the next section) to give an idea of which types of land cover are of the greatest concern.

<u>Forested Areas (Deciduous Forest, Coniferous Forest, and Mixed Forest):</u> 0% impervious
<u>Scrub/Shrubland:</u> From 2% for ungrazed land to 10% for moderately grazed pastureland
<u>Herbaceous:</u> From 10% for mowed lawns and moderately grazed pastureland to 25% for croplands
<u>Disturbed:</u> Varies greatly – from a low number for sandy areas to 100% for bare rock and cement
<u>Developed Land:</u> The area of the road surface itself is 100% impervious. The Virginia standard for road width is 50 feet, meaning that about half of the calculated area for most roads is taken up with 100% impervious surface (this percentage will be greater for major highways). The other portion varies from 10% for lawn to 100% for rooftops and parking lots.

<u>Forested Areas:</u> The least forested watershed in Fluvanna County, according to the Gap Analysis Land Cover, is F02, the South Anna River/Roundabout Creek watershed. This watershed contains only 37% forest, but covers only two very small areas of northern Fluvanna County, totaling 0.2% (Figure 1-1). All other watersheds in Fluvanna range between 60% and 72% forested, with the majority (42% to 46% of total land cover) of that being deciduous forest in all watersheds except H19, the Hardware River watershed, which contains a slight majority of coniferous forest (34% vs. 30%). It should be noted that the Gap Analysis Land Cover tends to overestimate forested areas. For example, nearly half of the City of Charlottesville and the adjacent urban area of Albemarle County are classed as forested areas.

<u>Scrub/Shrubland:</u> The greatest percentage of this is found in F02 (23%). Of the remaining watersheds, five of the nine have scrub/shrubland percentages between 15-16%. H17 (the James River/Totier Creek/Rock Island Creek watershed), H29 (Middle Rivanna River/Buck Island Creek), H19, and H32 (Cunningham Creek) contain 2%, 3%, 4%, and 8% respectively.

<u>Herbaceous:</u> Again, the largest percentage of this is found in F02 (38%). The next greatest percentage, 30%, is in the Hardware River watershed (H19). The other watersheds range from 21% (H29) to 9% (H33, the James River/Deep Creek/Muddy Creek watershed). Because herbaceous areas include categories of concern from an imperviousness standpoint such as grazed pasture land, croplands, and lawns, herbaceous area percentages are shown by third and fourth-order watershed (smaller, sub-watershed) in Figure 1-3. The two sub-watersheds with the greatest amount of herbaceous area are both found in the Hardware River watershed.

<u>Open Water:</u> None of the watersheds contain significant percentages of open water. The greatest is H20 (James River/Bear Garden Creek/South Creek), with 2.5%. The largest in terms of acreage is H31 (Lower Rivanna River/Ballinger Creek), which is not surprising as this watershed contains Lake Monticello, the largest impoundment in Fluvanna.

Disturbed: None of the watersheds contain significant percentages of disturbed land. The largest percentage is 2.5% in H17.

Coastal Wetlands: The largest percentage of coastal wetlands in Fluvanna is found in H30 (Mechunk Creek), with 3%. The largest area is in H31.

Developed Land: This was calculated separately from the other categories and should not be added together with them. It is only meant to give a rough idea of where the greatest development is located. The highest percentage of developed land is found in F02 with 19%. This is because each of the small segments of this watershed found in Fluvanna contains a road segment looping most of the way around it. Aside from F02, the largest percentage of developed land is in H33, with 15%, but this is also a watershed with a very small area in Fluvanna (0.3% of the county), and it contains most of the town of Columbia. All other watersheds in Fluvanna range from 8-11% developed land, with the greatest being H30 and the least being H34 (Byrd Creek). The largest area is in H31, not surprising given the presence of Lake Monticello, Palmyra, and parts of Fork Union and Columbia in this watershed. Developed land area percentages are shown by third- and fourth-order watershed in Figure 1-4; the most developed sub-watersheds are around Lake Monticello, but other relatively developed sub-watersheds are scattered throughout the County.

1.3.1.2 Rivanna River Basin Project Land Cover and Impervious Surface

This coverage (Figure 1-5) was developed by Ian Duncan and Elizabeth Campbell of the Virginia Department of Mines, Minerals & Energy - Division of Mineral Resources for the Rivanna River Basin Project. Data sources used included the Virginia Gap Analysis Land Cover, but for the portion of the basin in Fluvanna County also included SPOT imagery and Digital Raster Graphs, as described below:

SPOT Imagery

- panchromatic (gray tone) images with 10 meter pixels
- images rectified to account for topographic and geometric distortions based on 1:24,000 topography and control points.
- based on 1994/1995 images

Digital Raster Graphs (DRG's)

- raster images of 1:24,000 topographic maps
- based on data last updated by USGS in 1987 for most of watershed
- shows urban areas in generalized manner, shows individual houses in rural areas except in subdivisions
- data based on air-photo interpretation of high altitude photography

The land cover categories defined for the coverage are as follows:

Land Cover	Percent Impervious Surface
Forest	0
Ungrazed grass/shrubland	2
5+ acre residences in woodlands	3
2-5 acre residences in woodlands	5
Mowed lawns, moderately grazed pasture, golf courses	8
1 acre residences	10
Orchards	12.5
Grazed pasture lands	15
Croplands	18
0.5 acre residences	25
0.33 acre residences	30
0.25 acre residences	35
Townhouses	50
Apartments	70
Light commercial/industrial, schools, universities	70
Heavy commercial/industrial	90
Pavement, quarries	100

Although all of these categories probably exist somewhere in Fluvanna County, not all of them were found in sufficiently large areas (at least five pixels wide, or 150 meters) to be identifiable on the map. Thus, the land covers with the greatest percentage impervious surface that were mapped in Fluvanna County were cropland and half-acre residences, both at 25% impervious surface.

It can be seen in Figure 1-5 that the most significant area of impervious surface in the Rivanna Basin in Fluvanna County is found at Lake Monticello, with its half-acre residences. The sub-watershed containing Lake Monticello is the only one in the Rivanna Basin in Fluvanna with a greater than 10% average impervious surface. This sub-watershed has an average impervious surface of 12.5%, which places it at risk for degradation from runoff. The rest of the Rivanna

Basin in Fluvanna, according to the Rivanna Basin Project map, is covered primarily with a patchwork of forested areas, grasslands, and grazed pasture lands. Some lawns or moderately grazed pasture lands and one-acre residences are found, mostly in the northwest. The four hydrologic units of the Rivanna Basin in Fluvanna are relatively evenly matched with respect to land cover according to this coverage, with 70 - 72% forest and 3.2 - 4.3% impervious surface.

1.3.2 Priority Watersheds

In 1993, the study *Prioritization of Third and Fourth Order Watersheds in the Thomas Jefferson Planning District* was performed by the Thomas Jefferson Planning District Commission. This study identified watersheds where protecting the water quality is most important, but where the water quality is endangered by outside impacts and pre-existing sensitivity to these impacts. A total of nine factors describing watershed sensitivity and impact were examined:

Impacts:

- Nutrient Loading
- Permitted Discharge Points
- Landfills
- Swimmable/Fishable Goals
- Wetlands

Sensitivities:

- Water Intake Points
- Aquatic Species Listed by Virginia Department of Natural Heritage
- Wild & Scenic River Designation
- Sediment Delivery

Each of the factors was assigned points, which ranged up to three for maximum impact of a factor, so the maximum possible impairment (sensitivity + impact) score was 27. High priority watersheds were those with an impairment score of 14 or greater, medium priority watersheds had an impairment score of 6 to 14, and low priority watersheds had a score of less than 6. Additionally, the watersheds were grouped into three classes, based on use. Classes were broken down as follows:

Use Classification	Watershed Activities
Class 1	• State Scenic River • Designated Water Intake Point
Class 2	• Agriculture • Forest • Residential
Class 3	• Industrial/Commercial • Landfill • Permitted Discharge Point

Class 1 watersheds were those which were considered to require the highest water quality, based on the activities within them. Class 3 watersheds, on the other hand, were not considered to require high water quality because the activities within them did not need it. Class 2 watersheds were considered to be unknown in terms of whether high water quality was needed. The need for high quality water was recommended to be evaluated on a watershed-by-watershed basis, based on such issues as whether residents desired high water quality and the nature of forest uses (recreation vs. forest plantation) in the watershed.

The results of the Priority Watershed analysis are shown in Figure 1-6. Most of the Class 1 watersheds in Fluvanna are a result of the designation of the Rivanna River as a State Scenic River. Two watersheds (the southernmost watershed along the James River, and the most western watershed of the Rivanna River) contained water intakes. There was one Class 3 watershed, the one containing the Fluvanna County Landfill. Eight Class 1 watersheds (and none in the other two classes) were designated High Priority. These watersheds tended to have greater calculated amounts of nutrient loading, and greater areas of wetlands, than those designated Medium or Low Priority; additionally, four of them contained species listed by the Virginia Department of Natural Heritage. There were 18 Medium Priority watersheds (11 in Class 1 and 7 in Class 2). Many of these also had greater amounts of nutrient loading and wetlands; some also had high calculated amounts of sediment loading. Because scenic river designation and the presence of a water intake were considered to be sensitivities as well as reasons for Class 1 designation, only four Class 1 watersheds were determined to be Low Priority. It is interesting to note that the Lake Monticello watershed was designated Low Priority in this study. This was due in part to the low sediment delivery and moderate nutrient loading calculated for all residential areas.

1.3.3 Impacts of Mining on Water Quality

An historically significant, northeast-trending belt of sulfide mineralization runs form the southernmost tip of Fauquier County, through wester Spotsylvania County, central Louisa County, westernmost Goochland-easternmost Fluvanna Counties, and essentially terminates in

Buckingham County. Gold was mined in this region from 1804 until 1947. The gold industry in Virginia never recovered after World War II.

Mining activities are commonly associated with profound environmental impacts. More specifically, the mining and processing of sulfide mine ore bodies (in order to extract such metals as gold, silver, lead, and zinc) may be associated with:

- relatively high concentrations of metals in surface water and groundwater (antimony, copper, lead, zinc),
- reduced pH of surface water and groundwater, and
- mercury and cyanide contamination (as derived from amalgamation/cyanide processing).

Fluvanna County has been the site of a number of gold mines. Most of these were active in the nineteenth and early twentieth centuries. However, there is at least one (the Long Island/Pace Gold mine, near Palmyra) at which mining activities have resumed, and which has its own web page (http://www.woodstocknation.org/fluv.htm). Of the 75 that have been located (Figure 1-7), 33 were prospect sites, six were pit mines, 30 were shafts, five were adits (horizontal shafts), and one was a placer mine. Most of these were located in the Byrd Creek watershed in the eastern portion of the county, although there were 21 in the Lower Rivanna River/Ballinger Creek watershed, and one shaft in the James River/Bear Garden Creek/South Creek watershed. Of the various mine types, prospects and pits are least likely to have an impact on water quality, as these are exploratory features that are less likely to have had significant amounts of ore removed and processed, and thus are less likely to have residual materials on site that pose an environmental threat. On the other hand, shafts and adits are mines where some amount of ore was actually removed from the ground, possibly processed on site to some extent, with a likelihood that residual material exists today that could pose a threat to surface and groundwater. Placer mines involve the removal of minute particles of gold from stream-bed deposits of sand and gravel. Because of the in-stream nature of the mines, they have a particularly great potential to impact water quality, particularly if cyanide was used in the processing (not always the case). Details about on-site processing and the extent of the mines have not been recorded. Therefore, the only way to know for certain how much of a threat any of the gold mining sites in Fluvanna pose to water quality is to visit them.

2.0 FLUVANNA COUNTY GEOLOGY AND WATER WELL PRODUCTIVITY

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2.1 Overview

The quantity and quality of water that can be pumped from the ground at a given location is determined by physical characteristics of the soils, weathered rock material (saprolite), and bedrock that underlie the area (Figure 2-1). Groundwater occurs in soils, saprolite, and bedrock, and water wells can be constructed to tap water in each of these zones.

Hand-dug wells, and wells that are bored with an auger, penetrate soil and saprolite to maximum depths of about 75 feet, but not the hard bedrock beneath. These wells are vulnerable to seasonal fluctuations in the water table, and to contamination from surface waters. In general, shallow wells that do not penetrate bedrock are not viable for long-term domestic water supply.

Drilled water wells (Figure 2-1) tap sources of high quality groundwater in the bedrock, at depths of up to several hundred feet. These wells are cased, or sealed, from the surface downward through soils and saprolite to the top of the bedrock, in order to prevent direct infiltration of surface waters into the well. Ideally, the water that is pumped from a deep drilled well has spent a long time percolating downward through soils, saprolite, and the bedrock itself, and has been cleansed of biological and chemical impurities. Drilled wells are the best type of well for supplying domestic and industrial water needs.

Understanding the nature of the subsurface bedrock is critical to determining the quantity of groundwater that can be pumped from a drilled well at a given place. In some parts of the world, bedrock consists of sedimentary layers which have abundant pore spaces between individual mineral grains. These layers can form laterally extensive aquifers, or conduits for groundwater movement, that are at predictable depths, and from which seemingly unlimited quantities of high-quality groundwater can be pumped. In these areas, groundwater is the obvious solution for public water supply needs.

In contrast, the bedrock beneath Fluvanna County is very complex, and contains relatively few open spaces to conduct groundwater. In Fluvanna, extensive subsurface aquifers are rare, and both the quantity of water available at a given site, and the depth of the water-bearing zones, are highly variable and difficult to predict. Also, the wide variety of mineralogy and rock chemistry in a geologically complex area such as Fluvanna County can cause variations in groundwater chemistry that lead to water quality problems in some areas. Water well productivity and groundwater quality in Fluvanna are determined by a complex interplay among the bedrock aquifer, which supplies water to the drilled well, and the local soils and saprolite, which provide recharge and storage for the bedrock aquifer.

To evaluate groundwater availability and groundwater quality questions in Fluvanna County, we need detailed knowledge of the geologic formations that underlie the county, and knowledge of the hydrologic characteristics of water wells located in the particular rock formations. We also need knowledge of the thickness and character of saprolite and soils layers throughout the county. The Fluvanna County hydrogeologic database has been developed in this project as a tool with which to manage multiple types of data related to groundwater on a desktop computer. The hydrogeologic database is one of the most useful products of Phase 1 of this project. This database will be an invaluable tool for evaluating site-specific groundwater questions throughout the County in the years to come. The database and related software are being installed on computers at the Fluvanna County Health Department offices in Palmyra, where data from new wells can be entered into the database as received. The database will also reside at the Virginia Division of Mineral Resources (VDMR) offices and at the Thomas Jefferson Planning District Commission (TJPDC) offices in Charlottesville. VDMR anticipates having the database accessible via the Internet within the coming year.

At this writing, the database incorporates hydrologic data from 1326 domestic and 16 public water supply wells, of which 1003 wells have been precisely located in terms of latitude and longitude, and can thus be used in analysis of spatial relations (Figure 2-2). These include all water well records on file at the Fluvanna County Health Department in Palmyra, at the Virginia Division of Mineral Resources in Charlottesville, and at the Virginia Department of Health, Office of Water Programs in Lexington. In addition to water well data, the hydrogeologic database incorporates bedrock geology and topographic map data. Water well construction data in the database provides information on saprolite thicknesses throughout the county. With additional future work, the database could include hydrologic testing data, water chemistry data, and soils mapping.

2.2 Bedrock Geology

The Geologic Map of Fluvanna County (scale: 1:62,500, or 1 inch = 1 mile; Smith, J.W. and Milici, R.C., 1964, Virginia Division of Mineral Resources Bulletin 79, Plate 1) has been used as a geologic base for this study. This map was converted to a digital format, and can be used to subdivide the bedrock beneath the county into 18 unique geologic mapping units (Figure 2-3). Some of the rock unit names and descriptions have been modified from the original published map to reflect more recent mapping.

> Detailed synopsis of Fluvanna County bedrock geology:
>
> Fluvanna County is underlain by igneous and metamorphic rocks ranging in age from 300 million to more than one billion years. Bedrock in the western portion of the county consists of mica schist and phyllite that represent metamorphosed sandstone, siltstone and mudstone originally deposited in an Early Paleozoic (500 million years ago) ocean basin. East of Cunningham, phyllite and schist grade into quartz-mica schist and gneiss. The central portion of the County is underlain by metamorphosed volcanic rocks of the Cambrian-age (560 million years ago)

Chopawamsic Formation. The southeastern portion of the County from Carysbrook to Columbia is underlain by Cambrian- to Ordovician-age granodiorite, granite, and related gneisses. These rocks, and the Chopawamsic volcanic rocks, are overlain by Ordovician-age (450 million years ago) slate and quartzite of the Arvonia Formation. Chopawamsic volcanic rocks and the slates of the Arvonia Formation contain a series of gold and sulfide mineral deposits that were mined during the nineteenth and early twentieth centuries. These historic mine sites have implications for water quality, discussed in Section 1.3.3.

For purposes of studying County-wide trends in groundwater availability, the 18 different bedrock mapping units can be grouped into 6 rock families (Figures 2-4, 2-5). Each of these has distinct characteristics with respect to groundwater movement, water well productivity, water quality, and suitability of groundwater recharge. Fundamentally, all of the bedrock underlying Fluvanna County is crystalline rock that contains virtually no pore space between individual mineral grains. Groundwater occurs only within fractures in the rock (Figure 2-1). The density and geometry of bedrock fractures, and the ease with which groundwater can move through the fractures are critical to determining how much water can be extracted from wells penetrating bedrock. Fracture density and orientation varies among different rock types and from place to place within any one rock type.

Fractures are geometrically related to structural features is the bedrock such as folds, where the rocks have been crumpled by regional tectonic forces, and faults, which are abrupt discontinuities between blocks of bedrock. Surface observations of bedrock structures can be used to estimate fracture orientations in the subsurface; topographic lineaments defined on aerial photographs and topographic maps are also instructive. Throughout Fluvanna County, many of the boundaries between individual rock formations are faults, some of which are regionally extensive and have histories of multiple movement. In addition, the rocks have been tightly folded into a series of northeast-trending map-scale folds. The outcrop belts of the Arvonia Formation define three major folds in the central and eastern part of the county. In the western part of the county, the map pattern defines another series of folds. Folds and faults can coincide with increased fracture densities relative to surrounding rocks; this can be a useful tool for targeting areas favorable to groundwater productivity.

The phyllite and metagraywacke rock family contains fewer through-going fractures than do harder rocks such as quartzites, metamorphosed volcanic rocks and granite gneisses. However, within any of the individual bedrock families, there are locations where geologic structures, topography, and other factors relating to groundwater recharge result in little or no groundwater productivity, and other areas where fracture density and a combination of other factors support substantial groundwater yields.

2.3 Saprolite

Saprolite is thoroughly decomposed rock material that exists beneath near-surface soil horizons, and above solid, unweathered bedrock at depth (Figure 2-1). Most groundwater that flows into

water wells from bedrock fractures was derived from surface water percolating downward through soils and saprolite. Water well yields in crystalline rock are determined not only by fracture density in the bedrock, but also by the effectiveness with which water is stored in the saprolite and transmitted into fracture networks below.

The physical properties of saprolite that develops over a particular type of bedrock are determined by the manner in which the individual minerals that make up the rock behave in the weathering environment. Some common minerals such as quartz and muscovite are highly resistant to chemical weathering. Other common minerals such as feldspar, biotite, and amphibole weather readily to form hydrated clays. The nature and thickness of saprolite in a particular area controls not only that material's ability transmit groundwater into underlying bedrock fractures, but also the ability of the saprolite layer to cleanse groundwater of contaminants from surface waters such as drainfield effluents.

Granitic gneisses contain abundant quartz, muscovite, and feldspar. These rocks commonly weather to thick saprolite in which quartz and muscovite form a porous lattice around voids left by leached feldspars. This type of saprolite can be highly permeable with respect to groundwater, if the orientation of the residual lattice is suitable. A thick layer of this material can provide excellent storage for groundwater recharge. In contrast, some mafic composition volcanic rocks, which contain little or no quartz or muscovite, weather into relatively thin, clay-rich saprolite. This material can be relatively impermeable to groundwater, and does not make good storage or recharge material.

Paradoxically, the highly permeable granitic and gneissic saprolites that function best in terms of groundwater storage and recharge are also most susceptible to contamination by infiltration of surface waters, particularly drain field effluents. Clay-rich saprolite derived from mafic composition igneous rocks is a less efficient storage medium for groundwater recharge, but is also less vulnerable to contamination.

Saprolites are generally thickest in upland areas with gentle slopes, and thin to absent on steeper slopes adjoining stream drainages. Drainage bottoms commonly contain transported alluvial and terrace deposits sitting directly on bedrock. Depth-to-bedrock data in the water well database are a reliable indicator of saprolite thickness. These data indicate that on average, upland areas of Fluvanna County are underlain by at least 50 feet of saprolite. While average saprolite thicknesses are within about 20 percent of each other among the six rock families, the saprolites above quartz-mica schists and gneisses are thickest, averaging 58.4 feet. The significance of these numbers is that on average, there is ample thickness of saprolite in Fluvanna County for purposes of groundwater storage, and sanitary drainfield siting. However, planners need to be aware that variations in the type of saprolite can affect viability both in terms of groundwater recharge potential and in terms of the ability of the material to cleanse drainfield effluents.

Rock Family	Average Depth to Bedrock
Granitic gneiss	54.6 feet (n=71)
Mafic igneous rocks	53.0 feet (n=2)
Metamorphosed volcanic rocks	51.1 feet (n=138)
phyllite and metagraywacke	48.1 feet (n=439)
quartz-mica schist and gneiss	58.4 feet (n=217)
Slate and quartzite	53.3 feet (n=23)

2.4 Soils

The Fluvanna County Soil Survey maps of 1958 have not been rectified such that they can readily be incorporated into the hydrogeologic database. This severely limits evaluation of the relationship of Fluvanna soils to groundwater recharge, and groundwater vulnerability to contamination by drainfield effluents. It is strongly recommended that the County undertake to render the Fluvanna Soil Survey into a digital format such that in the future, soils data can be interfaced with the other data layers in the hydrogeologic database.

2.5 Water Well Database

The hydrogeologic database contains a total of 1342 records from water wells drilled in Fluvanna County. Locational accuracy is crucial to correlating water well data with geologic and other map data. At the time of this writing, 1003, or about 75 percent of these records have been located with sufficient precision to assign latitude and longitude values, and thereby include the records in spatial analysis. The process of incorporating future records into the database would be greatly enhanced if the well locations were precisely determined during the permitting process using Global Positioning System (GPS) technologies.

The water well database contains 40 discrete data fields; of interest in the present discussion are fields for well yield, total depth, and depth to bedrock. The yields that are reported on water well completion reports are initial yields, which are estimates made by drillers shortly after the well has been constructed. These initial yields are only an approximate indicator of how a well will perform under continuous pumping over periods of months or years. The sustainable yield of a well is the amount of water that can be pumped on a continuous basis over time without exceeding local recharge. Generally the sustainable yield of a well is a smaller quantity than the reported initial yield.

One of the problems in working with the yield data is that relatively few “dry holes”, or failed attempts to find water, are reported by drillers to the Health Department. The database contains only 13 records for which the reported yield is zero. This does not represent a statistically valid sample set for purposes of this study. There undoubtedly have been far more than 13 dry holes drilled in Fluvanna County over the past 25 years or so during which records have been kept. Notwithstanding the under-representation of "dry holes", when reported yields are averaged for all wells occurring in various geologic formations or rock families, the resulting numbers do give an indication of the relative groundwater productivity. Average yields for domestic wells drilled in the six Fluvanna rock families are a general indication of relative groundwater potential in different parts of the county:

Rock Family	Average Yield, Domestic Drilled Wells
granitic gneiss	14.1gpm (n=64)
Mafic igneous rocks	10.0gpm (n=1)
metamorphosed volcanic rocks	12.3gpm (n=133)
phyllite and metagraywacke	8.0gpm (n=368)
quartz-mica schist and gneiss	12.0gpm (n=157)
slate and quartzite	17.0gpm (n=25)

These average yields are consistent with geological considerations. Slates and quartzites have tended to fracture in a brittle manner in response to regional tectonic stress over time; consequently these rocks have significant potential for maintaining open fracture systems to serve as conduits for groundwater. On the other hand, phyllites and metagraywackes have tended to bend or fold rather than break under the influence of regional tectonic stress; these rocks have lower fracture densities than any of the crystalline plutonic, volcanic, and gneissic rock families.

There are a total of 22 drilled wells in the database for which reported initial yields are 50 gallons per minute or greater (Figure 2-6). The distribution of these wells with respect to rock family displays a trend similar to that of averages of reported yields, where the greatest percentage of high-yield wells occur in slate and quartzite, granitic gneiss, and metavolcanic rocks. The distribution of high-yield wells is a good indication that substantial groundwater resources do occur in locations that are scattered across Fluvanna County. Further detailed investigations of the geologic settings and recharge characteristics of these wells would be very helpful in locating other areas of the county where groundwater potential is favorable.

Three of the high-yield wells within slate and quartzite are public water supply wells operated by the Fork Union Sanitary District. These wells have larger diameters than most domestic wells, which enhances productivity. Nonetheless, the relatively high percentage of high-yield wells within the slate and quartzite rock family is an indication that groundwater potential is favorable is these rocks. A reported decline in productivity of some of the FUSD wells in recent years is likely related to pumping in excess of recharge rates. Unfortunately, the relatively high

manganese content of several of these wells is probably related to manganese oxides in the quartzite bedrock, and other wells drilled in these rocks are likely to produce similar groundwater.

Total depths of drilled wells in the database range 65 feet to 1101 feet; the median depth is 170 feet. High-yield wells range in depth from 105 feet to 505 feet. The relationships between well yield and total depth are displayed in the table below. With the exception of the phyllite and metagraywacke rock family, maximum average yields occur at depths greater than 100 feet. The slate and quartzite family shows a trend of increasing yield with depth, and maximum yields occur in wells drilled deeper than 300 feet. Five of the wells drilled deeper than 300 feet in slate and quartzite were developed as public water supply wells. The remaining rock families show maximum average yields for well depths between 100 and 300 feet.

Rock Family	Avg Yields, TD <100 FT	Avg Yields, TD 100-200 FT	Avg Yields, TD 200-300 FT	Avg Yields, TD >300 FT
Granitic gneiss	4.0 (n=3)	19.4 (n=23)	11.0 (n=25)	13.0 (n=16)
Mafic igneous rocks		10.0 (n=1)		
Metamorphosed volcanic rocks	6.0 (n=9	13.7 (n=53)	16.8 (n=44)	4.4 (n=28)
Phyllite and metagraywacke	12.4 (n=50)	10.1 (n=173)	5.7 (n=90)	2.9 (n=61)
quartz-mica schist and gneiss	11.8 (n=32)	16.2 (n=77)	7.3 (n=32)	3.9 (n=18)
Slate and quartzite	5.0 (n=3)	18.5 (n=14)	24.4 (n=5)	89.0 (n=8)

It is commonly believed that there are diminishing returns from drilling wells to depths greater than about 400 feet because theoretically, the confining pressures that increase with depth, tend to close bedrock fractures supplying groundwater to the well. While this may be true in the case of relatively soft rocks such as phyllite and metagraywacke (as evidenced by this study), harder rocks such as slate, quartzite, and granitic gneiss can maintain open fractures at depths considerably deeper than 400 feet. There may be substantial groundwater resources in some areas of the County that could be accessed at depths of 800 or more feet. Any groundwater exploration program undertaken in the future should include one or more deep test wells.

2.6 Evaluating Groundwater Resources in Potential Development Areas

The averages of reported initial yields help to characterize groundwater potential in different parts of Fluvanna County, but do not provide absolute criteria with which to evaluate groundwater availability on specific sites. The averages do not, for example, guarantee that every 200-acre subdivision on slate and quartzite bedrock can expect to obtain a sustainable 24.4 GPM yield from each of 200 individual domestic wells drilled to a depth of 300 feet. In fractured rock aquifer terrain, groundwater storage, recharge, and transmissivity in one area may be quite different from the aquifer parameters a short distance away, even within the same geologic formation. Somewhere in Fluvanna County there undoubtedly exist 200-acre parcels on slate and quartzite bedrock for which little or no groundwater is available.

Evaluating groundwater potential for a given parcel of land, and choosing the best well site on that parcel is not a matter of guesswork. Groundwater availability is in part a function of the local bedrock's ability to efficiently transmit groundwater from the recharge area to a well site. However, the size of the recharge area, and thickness and permeability of the local saprolite layer as a storage medium are also critical in determining how much of a sustainable yield can be anticipated from a given well site. In fractured rock aquifer media, which pertains to all of Fluvanna County, the down gradient or "down hill" direction of groundwater flow is roughly consistent with surface topography. This means that the recharge area for a given well site generally corresponds to the surface drainage area topographically "upstream" from the well site. Wells that are sited on the tops of hills or ridges can be predicted to have far less extensive recharge areas than wells sited in valleys.

Saprolite thickness and character can be evaluated by studying casing-length data in the hydrogeologic database, and by examining soils mapping data for estimates of permeability. Obviously, bedrock exposures at the surface are evidence that saprolite is locally absent, with the implication that the saprolite layer may be very thin in those areas where bedrock is not exposed. The type of surface cover also has a profound effect on the accessibility of rainwater striking the surface to groundwater recharge. Rainfall hitting an asphalt parking lot has no access to the subsurface; clearly, asphalt is not an ideal surface cover medium for a groundwater recharge area. Cleared and closely cropped farmland, where topographic relief is high, can also promote rapid runoff of rainwater, and limited infiltration for groundwater recharge. A mature forest represents the optimal land cover for a groundwater recharge area.

The only way to evaluate with some degree of certainty the hydrogeologic regime of a particular site is to conduct hydrologic testing using existing or new wells. Hydrologic tests are designed to measure groundwater flow and storage characteristics; tests can be designed using single wells, or multiple wells on adjacent sites. Typically, electronic devices are installed in the well or wells to monitor water levels, and a well is pumped at a known rate for a period of time. Changes in water levels in the wells over time are charted through the test, and mathematical formulae are then applied to define the aquifer parameters. Hydrologic testing is the only way one can accurately assess the sustainable yield of a given well, or what effect, if any, introduction of a new pumping well will have on water availability in existing nearby wells. In the future, the County should consider requiring hydrologic tests prior to approving applications for high-density subdivisions dependant on groundwater.

3.0 WATER RESOURCE PROTECTION

3.1 General Information

Water resources in Fluvanna County are somewhat limited. In order to maximize the potential of long-term water resources, rivers and streams, groundwater supplies, and impoundments should be protected from adverse effects from human activity. Although no impoundments in Fluvanna County are currently being used as public water sources, impoundments were mentioned as a possible component of the water system by Timmons (*Water Resources Study for the Zion Crossroads Area,* 1996; *Water & Wastewater Preliminary Engineering Report and Facilities Master Plan, County of Fluvanna*, 1998), particularly if use of the Rivanna as a water source is increased. Protection of existing and future non-water-supply impoundments is important as well, in order to maintain their recreational and aesthetic value and to protect the streams and rivers into which they discharge. Protection of these resources will rely on control of point and non-point sources of pollution, either from development or other ground-disturbing activities.

Public policy in Fluvanna County should be consistent with the following three goals:

1. Protect and maintain the water quality of Fluvanna County's streams and rivers;
2. Protect and maintain the water quality in Fluvanna County's groundwater supply areas; and
3. Protect and maintain the water quality in present and future Fluvanna County impoundments.

Strategies more fully described in following sections of this chapter include:

- Decreasing runoff
- Use of natural vegetative buffers
- Decreasing nutrient loading
- Continuing Geographic Information System (GIS) mapping of land characteristics and well locations; beginning septic location mapping
- Examination of old mining sites and underground storage tanks (USTs)
- Increasing water quality testing and research
- Increasing use of Best Management Practices (BMPs)
- Developing site-based zoning and delineation of areas suitable for various development types
- Improving septic system management
- Instituting a wellhead protection program
- Enhancing partnerships with agencies responsible for developing and educating the public about strategies for water protection
- Encouraging water conservation
- Encouraging public involvement

3.2 GOAL ONE: Protect and maintain the water quality of Fluvanna County's rivers and streams.

The primary sources for public water supply in Fluvanna County within the foreseeable future have been identified to be the Rivanna and James Rivers (Timmons, *Water & Wastewater Preliminary Engineering Report and Facilities Master Plan*, *County of Fluvanna*, 1998). As outlined in Section 1.2.1, these rivers have already demonstrated problems with fecal coliforms, suspended solids, phosphorus, and pH, particularly during storm flow. Because much of the watersheds of these rivers lie outside Fluvanna's boundaries, Fluvanna needs to work with upstream localities to be certain that its water supply is protected. However, Fluvanna should also act within its own borders to protect the rivers.

In accordance with the river protection strategies presented in this section, a river protection program should be implemented as soon as possible for both of the County's potential water sources and their major tributaries.

To undertake river protection planning for the Rivanna and James Rivers, Fluvanna County should:

research the existing land uses along the James and Rivanna Rivers,
prepare a general management plan utilizing the techniques discussed in this section, and
meet with upstream localities to develop a cooperative river protection plan that all localities are willing to adopted and enforce.

<u>3.2.1 Strategy: Delineate protection areas for rivers.</u>

In recognition of the value of trees in controlling site runoff and the need for vegetated buffers, the Virginia Department of Forestry's Forestry Best Management Practices for Water Quality in Virginia handbook recommends Stream Management Zones (SMZ) on both sides of the banks of perennial streams/rivers and bodies of open water in order to protect bank edges and water quality. Vegetated buffers (or "filters") of trees, shrubs and grasses have been shown to slow storm water runoff and encourage percolation, thus reducing the volume of storm flow, while filtering 70 - 80% of water borne pollutants. "Buffer strips create stable stream flow, stabilize stream banks, reduce suspended sediment and turbidity, lower summer water temperatures, and filter chemical and organic pollution. They can also slow topsoil loss from agricultural area, combined with erosion prevention practices on farmland. A healthy riparian zone also benefits terrestrial wildlife." [Waters, T.F. 1995. Sediment in Streams: Sources, Biological Effects and Control. American Fisheries Monograph 7.] Buffer areas would serve to reduce sediment and phosphorus runoff, which are problems in Fluvanna County (discussed in Section 1.2.1) at high flows.

The width of corridor needed to adequately protect the rivers and their major tributaries should be determined, based on geological and biological parameters.

Studies in other areas have concluded that 100 feet is a useful standard for buffer width. However, a wider protection area should be considered, with restrictions on adjacent land uses, in the upstream vicinity of water supply and proposed water supply intakes.

Stream Management Zones should include vegetative buffers along the stream/river banks. The continuation of buffers should be ensured where they naturally exist; buffers should be developed where non-existing.

Mechanisms should be put into place to promote the establishment of buffers, in a manner that is fair to riparian landowners. Policies, such as land use taxation, should be implemented to encourage their development.

A priority list of locations for the implementation of stream buffers should be developed. Considerations to take into account include existing condition, effect on water quality, feasibility, watershed priority (see next section), and relationship to existing/potential water intake location.

Annual targets for streambank restoration and improvement should be established. Agencies such as the Virginia Department of Forestry and the Thomas Jefferson Soil & Water Conservation District should be partners in the effort to meet those goals.

<u>3.2.2</u> <u>Strategy: Promote forestal uses along the rivers.</u>

Forestal uses have been shown to provide the best buffering for water resources. These may be promoted through designated land uses and the use of land use taxation.

Land use taxation should be supported, provided Best Management Practices are used.

C*onservation easements along the rivers and their major tributaries should be encouraged, particularly in high and medium priority watersheds.*

High and medium priority watersheds (actually, third or fourth order “sub-watersheds”) are determined by a scoring system involving a variety of factors (see Section 1.3.2). In 1993, eight high priority and 18 medium priority watersheds were found in Fluvanna County (out of a total of 98). Factors which made them higher priority than other watersheds include: containing a water intake, containing a segment of designated scenic river, greater calculated amounts of nutrient and/or sediment loading, greater amounts of wetlands, and presence of species listed by the Virginia Department of Natural Heritage. These are all good reasons to protect these watersheds by the use of conservation easements (as well as by other measures).

3.2.3 Strategy: Perform further monitoring and research to determine the extent, sources, and impacts of pollution problems.

The Rivanna River Basin Project data (Section 1.2.1.2) indicates that water quality, which is generally acceptable during base flow, deteriorates to below-acceptable levels during stormflow. However, more information is needed to determine the extent of the problem. How much storm runoff does it take to violate water quality standards? How many days does it take pollution levels to return to acceptable? Are the spikes in pollution levels that are occurring sufficient to affect the river's biotic community? What are the long term effects on the water as a drinking water supply? How do these conditions affect the recreational/tourism use of the Rivers?

The County should seek partnerships with other agencies to ensure that water quality monitoring is appropriately conducted in the County.

Monitoring stations and gauging stations should be co-located, so that water quality data can be tied to water quantity data.

Monitoring should be timed with regard to storm events. The DEQ should quantify levels of pollutants during the first flush of a storm event to assess the impact of these chemical peaks on aquatic life.

Regular surveys of river/stream biota should be conducted in order to monitor trends in the riverine community.
The continuing monitoring of benthic macroinvertebrates at sites in the Rivanna Basin should be supported, and sites should be established in the other watersheds in the County. Regular sampling of fish species should be conducted by the Virginia Department of Game and Inland Fisheries.

A TMDL (Total Maximum Daily Load) should be developed and implemented for the fecal coliform problem in the Rivanna River.
The Rivanna River, from Moores Creek (in Albemarle County) to the confluence with Mechunk Creek in Fluvanna, is on Virginia's Impaired Waters 303(d) TMDL priority list due to excess concentrations of fecal coliforms (a problem also discussed in Section 1.2.1). Development of a TMDL should include determination of the sources of the contamination, allocation of permissable daily loads to the sources, and an implementation plan. Particular focus should be placed on the area upstream of the Rivanna River Basin Project's Leslie site, which is within this reach and which had a fecal coliform count over 100 times the Virginia Water Quality Standard.

Explore possible TMDL listing and development for other river segments in Fluvanna County.
Although the Rivanna from Moores Creek to Mechunk Creek is the only river segment in Fluvanna on the TMDL list for fecal coliforms, both DEQ and Rivanna River Basin Project data indicate that other river segments may have fecal coliform problems as well. More extensive monitoring should be performed to determine whether other waterways are impaired, and

TMDLs developed if needed.

It should be determined whether the high turbidity readings in the James and Hardware Rivers are due to suspended sediments (as seems likely). Major sources of sediment runoff should be identified throughout the County and targeted for vegetated buffer planting. A review of the eroision and seidment control program imlementation and enforcement should be undertaken.

Possible sources for the high pH along the Hardware River should be identified, and, if possible, remediated.

3.2.4 Strategy: Evaluate the effect of old mines in Fluvanna County.

Detailed investigations should be undertaken to assess the extent to which old mines could diminish the water quality of feeder streams.

Additional stream monitoring stations should be put in place following the mine investigation and monitoring for heavy metals and other identified contaminants carried out on a regular basis.

3.2.5 Strategy: Implement a septic tank management program.

Because septic tank management affects both surface water and groundwater, but has a greater impact on groundwater, this topic is covered in Section 3.3.5. The recommendations in that section apply to surface water protection as well.

3.2.6 Strategy: Decrease non-point sources of pollution

3.2.6.1 Land Disturbing Activities

Land disturbing activities are major causes of soil erosion and provide opportunities for increased non-point source pollution. Most land disturbing activity requires a permit from the County.

When seeking approval of a project which disturbs land, the applicant should demonstrate that:

> *a) no more land shall be disturbed than is necessary to provide for the desired use or development;*
>
> *b) indigenous vegetation shall be preserved to the maximum extent possible consistent with the use and development allowed.*

Funding of the Soil Erosion and Control Program in Fluvanna County should be continued.

Prior to a subdivision receiving approval, the applicant should demonstrate sustainable water yields consistent with the proposed use.

3.2.6.2 Stormwater Management

Runoff is that portion of the rainfall that does not infiltrate the soil (and become groundwater) or become captured in local depressions. It is a key component in the local and regional water budget. Stormwater runoff in urbanized or urbanizing areas is a significant source of non-point source pollution. Contaminants introduced into state waters from diffuse activities and locations are collectively called "non-point" source (NPS) pollution.

Runoff also has implications for groundwater. The greater the percentage of rainfall that flows away as runoff, the less groundwater recharge occurs in a given area. In naturally vegetated areas, stormwater gets trapped by vegetation and slowly soaks into the ground. In contrast, in areas intensively affected by human activities, stormwater travels preferentially by overland flow, becomes channelized by drains and ditches, and is rapidly discharged into streams and impoundments. Such channelized flows have high velocities which entrain (take along with the flow) sediment and pollutants, increase erosion and siltation, and have a negative effect on aquatic ecology, particularly native fish populations. For example, in the Rivanna River Basin Project data for Fluvanna County (Section 1.2.1.2), phosphorus, fecal coliforms, and total suspended solids show a strong positive correlation with times of high runoff.

As development occurs, stormwater management programs have handled the increased volume, velocity and flow rate of runoff by requiring developers to construct on-site ponds and drainage systems that control one or more of the runoff characteristics. In some cases, localities have conducted regional stormwater management studies and publicly funded stormwater improvements including elaborate drainage systems, channeled watercourses, dams, and reservoirs.

In 1989, the General Assembly passed the Stormwater Management Act (10.1-603.1 et seq., *Code of Virginia*) that provides localities authority to adopt local stormwater management ordinances consistent with minimum state regulations. Most localities have required stormwater management for years to control flow volume and velocity through erosion and sediment control ordinances and flood plain regulations. Until passage of the Stormwater Management Act, and subsequent amendments, no clear authority for localities to protect water quality was available.

Experience with what has become "conventional" stormwater retention pond design throughout the Commonwealth has shown them to be both aesthetically objectionable and somewhat hazardous to health and safety. As Fluvanna County works to develop effective methods of stormwater management, significant consideration should be given to alternative techniques, such as temporary retention in parking lots, improved designs for drainage structure, and regional stormwater basins.

The County should begin the development of a stormwater management program in growth areas, such that the post development non-point source pollution load does not exceed existing conditions.

> *Such calculations should be on the site as a whole, not an individual lot. Pre-development calculations should reflect the load from the entire unplatted parcel. Post-development calculations should reflect the total of impervious surfaces for all platted parcels assuming a complete build out of the project. BMPs will be designed and implemented to mitigate the increased load for the entire development.*

A promising mechanism of funding a stormwater management program is the concept of a local stormwater utility. Such a utility functions like any other public service district and its existence reinforces the concept that control of non-point source pollution is fundamentally no different than the services provided by other public utilities.

Utility fees may be based on the extent of impervious cover on a parcel, since problems with stormwater quantity and quality are directly proportional to the amount of impervious cover. Typical charges to the landowner might average $2.00 to $5.00 per month, with higher rates for industrial and commercial sites.

Most importantly, when BMPs are approached as a public utility, fees can be directed toward watershed-wide stormwater management planning, purchase of land for regional stormwater management facilities, construction and maintenance of such facilities, and staffing the local stormwater management program.

3.2.6.3 Impervious Surfaces

As mentioned in Section 1.3.1, stormwater runoff into rivers, streams, and lakes increases with the amount of impervious surface. Impervious surface of 10% or less has not been found to negatively impact water quality or aquatic biology. Watersheds with impervious surfaces greater than 10% have been found to correlate well with declining aquatic biology diversity and impaired water quality. As discussed in Section 1.3.1.2, only one of the sub-watersheds in the Rivanna Basin in Fluvanna (that containing Lake Monticello) has an impervious cover over 10%. The analysis performed in Section 1.3.1.1 found the Lake Monticello sub-watershed to be by far the most developed watershed in the County, so it seems unlikely that any other watersheds in the County exceed 10% impervious surface at this time. However, as development proceeds, the combined effect of urban and agricultural land uses may rapidly lead to significant increases in local runoff and associated environmental problems.

Develop a land cover/impervious surface map for that portion of the County outside of the Rivanna Basin. Both the proposed map and the existing Rivanna Basin map should be field checked and updated regularly.

Imperviousness should be targeted to no more than 10% per sub-watershed.

The County should consider including the following Best Management Practices (BMPs) in developing a runoff control program or integrating specific actions in existing ordinances or *programs such as the Soil Erosion and Control program to counteract the effect of impervious surfaces:*

- Protection of existing natural areas in urban and suburban areas
- Use of drip hoses, not sprinklers
- Reduction of paved areas
  - Minimized road widths
  - Vegetated swales in lieu of concrete gutters, catch basins and underground storm water piping
  - Use of porous block or gravel
- Creation of artificial wetlands to capture runoff
- Use of sand filters in stormwater detention facilities
- Developing a cost/benefit analysis for controlling runoff
- Use of vegetation as buffers, catchment areas, ground cover on steep banks
- Use of deep-rooted native plants to promote infiltration and develop healthy soil
- Use of gravel, sand, or rain gardens to trap roof runoff
- Use of constructed wetlands to trap sediment, slow the progress of runoff and filter pollutants
- Use of BMPs associated with agriculture that reduce runoff
- Citizen involvement as educators concerning use of BMPs

The County should review local zoning and planning ordinances for obstacles to achieving reduced imperviousness.

3.2.6.4 Pesticide-Herbicide-Nutrient Management

Source control is one of the most important methods of reducing non-point source pollution. For example, to reduce nutrient runoff (nitrogen and phosphorus, the latter of which has exceeded advisory standards at every monitoring station in Fluvanna [Section 1.2.1]), BMPs are available which include:

- Timing and placement of fertilizers for maximum utilization by plants and minimum leaching or movement by surface runoff.
- Soil testing and plant analysis to avoid overfertilization and subsequent losses of nutrients in runoff.
- Use of slow release fertilizer.

Pesticide runoff reduction measures include:

- Integrated Pest Management, including use of biological controls.
- Correctly applying pesticide, including spraying when conditions for drift are minimal and avoiding application when heavy rain is forecast.
- Selecting pesticides which are less toxic, persistent, soluble and volatile, whenever feasible.
- Use of plant varieties that are resistant to insects, nematodes, diseases, etc., in order to reduce pesticide use.

Many other BMPs are available.

Minimization of agricultural, lawn, and garden chemical runoff through reduced use, careful selection and controlled application should be encouraged.
Partnerships should be formed with the Thomas Jefferson Soil and Water Conservation District and the Fluvanna County Cooperative Extension Service to educate farmers, grounds managers and homeowners on ways to reduce chemical runoff.

3.2.7 Strategy: Protect in-stream flows.

The in-stream flow required to avoid degradation of habitat quality and the present and historic flow conditions should be carefully studied before any decisions are made with regard to withdrawal of additional water, particularly from the Rivanna River.
Some concerns have been raised about existing flow conditions and trends along the Rivanna; see the Rivanna River Basin Project's report, *State of the Basin: 1998*, for more details.

3.3 GOAL TWO: Protect the Groundwater Quality in Fluvanna County.

3.3.1 Strategy: Delineate areas where residents rely on groundwater, particularly in higher density areas. Identify areas in which groundwater problems already exist.

A database and GIS coverage, which includes well locations and such information as well yield and depth to bedrock, have been created as a part of this project. Maps showing well locations and high-yield wells can be found in Chapter 2.

Maintain hydrogeologic database by updating with new water well records.

Expand hydrogeologic database to include hydrologic testing data, water chemistry data, failed septic field data, and soils information.

3.3.2 Strategy: Delineate areas in which groundwater is particularly vulnerable to contamination.

In three other localities of the Thomas Jefferson Planning District, a DRASTIC analysis was performed to determine areas in which the groundwater is most susceptible to contamination, based on the following parameters:

- Depth to water
- Recharge
- Aquifer Media
- Soils
- Topography
- Impact of Vadose Zones
- (Hydraulic) Conductivity

Such an analysis can provide a map of areas in which activities which might contaminate the groundwater, such as pesticide application, should be avoided.

Perform a DRASTIC, or similar, analysis for Fluvanna County.

Consider restricting groundwater-threatening activities in areas of greatest groundwater vulnerability.

<u>3.3.3 Strategy: Institute a wellhead protection program.</u>

To maintain a reliable supply of well water, public or private, it is important to institute good practices and protection in the area surrounding the well to minimize the potential for pollution. Programs such as this are known as wellhead protection programs. The area designated for protection depends on the nature of the soils, the rates of withdrawal, existing land use, future land use, and the consequences of contaminating the subject well.

If adequate information is not available, estimates of the area to be protected may be used. The Lord Fairfax Planning District Commission has proposed radii of 300 feet to 1500 feet, the smaller areas being associated with the most restrictive institutional controls.

A wellhead protection program should be instituted that:

- *identifies public wells*
- *defines recharge areas*
- *restricts development within recharge areas*
- *restricts the use of pesticides, nutrients, and other pollutants in recharge areas*

<u>3.3.4 Strategy: Avoid the use of groundwater that has been contaminated by Leaking Underground Storage Tanks (LUSTs).</u>

Underground storage tanks should be located and mapped on a GIS.

Nearby wells should be tested for contamination.

Future wells should be sited away from USTs, if possible.

USTs should not be sited in wellhead protection areas.

<u>3.3.5 Strategy: Develop a septic system management program.</u>

Septic systems have been identified by EPA as the most frequently reported sources of groundwater contamination in the United States. *Evaluation of Household Water Quality in Fluvanna County, Virginia* (Virginia Tech, 1998) found *E.coli* in about 20% of private wells tested, and it is likely that many of those wells were contaminated by septic systems. A properly designed, installed, maintained, and utilized septic system, however, should function well for many years.

Septic systems function by providing both anaerobic (without oxygen) and aerobic (with oxygen) treatment of biological wastes. This treatment is provided by micro-organisms. Solids are transferred from commodes to the septic tank via household plumbing. Within the septic tank the solids are combined with all other household wastewater from the kitchen, bath, and laundry. The solids are partially liquefied and digested within the anaerobic environment of the septic tank. Lighter materials float on top of the liquid in the tank and form a scum layer. Each time the septic tank fills up the overflow goes first into a distribution box and than into parallel lines of perforated pipe or open-jointed tile. These "lines" are placed in trenches partially filled with gravel and completely surrounded by soil. These trenches make up the drain field of a conventional septic system.

Aerobic treatment of the wastewater takes place in the soil of the drain field. If the septic tank is not pumped out, it will eventually fill up with solids. Solids will begin to be transported into the trenches and, over time, will clog the soil pores. Septic system "failure" will occur when sufficient solids have infiltrated into the soil pores to cause sewage to leach out onto the surface or back up into the residence that the system serves. Rehabilitation of a drain field which has failed due to solids infiltration is often either impossible or ineffective, and is extremely expensive even where it can be done. In addition, long before this type of failure occurs, inefficient treatment of the wastewater may have occurred for a number of years. The EPA recommends an average pump out frequency of three to five years for conventional septic systems in order to maintain efficient effluent treatment.

The County should require that septic fields within the groundwater protection and river corridor areas be pumped every five years.

> *Tanks should be inspected every four years. If sludge equals 1/3 of the volume of the tank, the tank should be pumped at that time. If it is greater than 1/3 of the volume, it should be pumped and re-inspected in two years. Contractors should provide a letter of inspection to the public health sanitarian.*

The ability of septage haulers to dispose of septage at an appropriate treatment facility throughout the year should be ensured.

Private septic fields should be identified and mapped using GIS.

Water quality data should be gathered and analyzed in areas where septics are known to fail.

Pump-out alone will dramatically extend the life of a sewage disposal site. Nevertheless, failure will take place eventually although with very different consequences. In conventional drain fields, a biological mat builds up at the gravel/soil interface in the drain field trench. After many years, this mat, which is very important for providing treatment of the effluent wastewater, becomes too thick for water to pass through it. System failure will occur in this situation as with a system which has not been regularly pumped out.

System failure caused by biological mat buildup alone is not permanent. If solids have not infiltrated into a disposal site or if components of the on-site sewage treatment system have not been damaged, the disposal site can often be reclaimed merely by temporary cessation of use, allowing the biological mat time to break down. The amount of time necessary to reclaim a sewage disposal site in this manner may be very brief or as long as several years, depending on the amount of biological mat buildup. For this reason, a reserve area should be available in order to continue the use of a given system and maintain residency on an affected property.

Alternate drain fields for septic systems should be required.

3.3.6 Strategy: Implement site-specific carrying capacity residential zoning.

The carrying capacity of a tract of land, in terms of dwellings per acre relying on individual water wells and drain fields, is determined by the nature of local soils, saprolite, and bedrock geology. For each set of conditions, there exists a minimum lot size, or maximum density for residential development, beyond which problems of drain field failure, water well contamination, or declining water well yields may occur.

The principal goal of residential zoning is to protect the health, safety, and welfare of the citizens. Protection of groundwater supplies falls under this statutory requirement. Often this protection is realized through specifying minimum lot sizes.
It is suggested here that allowable lot sizes be decided based on the carrying capacity of the land in order to protect the groundwater supplies.

Minimum lot sizes should be determined based on careful consideration of factors such as soil type, saprolite type and thickness, bedrock geology, and slope that pertain to specific parcels of land. The complex distribution of different soils, saprolite, and bedrock in Fluvanna County means that the minimum lot size appropriate in one part of the county is not necessarily appropriate in other parts of the county.

This goes beyond the minimum requirement for percolation and takes into consideration the ability of the land to filter out contaminants before reaching the groundwater levels. Ground that percs well may allow such rapid absorption of the wastewater that it is not cleansed before reaching the groundwater.

GIS makes it possible to accurately overlay the spatial data in the preceding paragraph. The hydrogeologic database Included in this study uses GIS technologies to study the relationship of water well productivity to geology. The existing database could be expanded to include soils data, elevation data, and septic field failure information. This would be the basis of a site-specific carrying capacity zoning ordinance to protect groundwater supplies and which is consistent with the protection of health, safety, and welfare.

A Site-Specific Carrying Capacity-based Zoning Ordinance should be developed by:

A. Assigning values to individual mapping units pertaining to the following attributes for the purpose of identifying drain field suitability:

1. Evaluate individual soils units with respect to drain field suitability

Consider physical properties that affect the ability of soils to clean wastewater as it passes through. These properties include permeability, cation exchange capacity, oxygenation potential.

2. Evaluate bedrock geologic formations with respect to aquifer suitability.

Consider factors such as fracture density and rock chemistry that affect groundwater productivity, groundwater chemistry.

3. Evaluate saprolites related to bedrock types in terms of groundwater storage/recharge suitability.

Consider physical and chemical factors that affect the ability of different saprolites to transmit groundwater; create derivative digital layers based on saprolite types. Contour casing length data from water well database to create a saprolite thickness map.

4. Create slope map from digital elevation data. Evaluate water well and drain field suitabilities in terms of slope.

B. Refine suitability values through investigation of known cases of domestic drain field and water well failure to determine causal relationship to soil type, saprolite, and geology.

C. Flag high-risk sets of conditions.

D. Assign appropriate minimum lot sizes to ranges of aggregate "drain field stability" values, requiring larger lots where high-risk sets of conditions are present.

3.4 GOAL THREE: Protect and maintain the water quality in present and future Fluvanna County impoundments.

In general, strategies which have been recommended for protection of rivers and streams will work just as well for impoundments, if applied within their watersheds. As discussed in Section 3.2, these include:

- Buffering with vegetation
- Obtaining conservation easements
- Septic tank management within the watershed
- Reducing land disturbance

- Managing stormwater
- Reducing impervious surfaces
- Managing pesticides, herbicides, and fertilizers.

Delineation of the watershed boundaries is an important first step in impoundment protection.

Should the County ever build an impoundment for drinking water purposes, it is recommended that its drainage area be delineated and declared a Watershed Management Area. Within the Watershed Management Area, the above strategies should be requirements.

3.5 GENERAL: strategies which cut across protecting rivers and streams, groundwater, and impoundments.

3.5.1 Use Best Management Practices

Best Management Practices, BMPs, have been developed for forestry, stream protection, agriculture, and wellhead protection. A few examples of BMPs were given in Sections 3.2.6.3 and 3.2.6.4. BMPs may range from simple and even money-saving measures such as many of those listed in Section 3.2.6.4 to expensive structural solutions such as retention basins. Use and implementation of BMPs would go far toward preventing pollution in Fluvanna County. To do so may in some cases require plan adoption and implementation.

Form partnerships with agencies to implement and educate about BMPs.
Partnerships with agencies such as the Soil and Water Conservation District, the Farm Bureau, the Health Department, the State Water Control Board and others will provide needed assistance and support for the County and its citizens in determining appropriate BMP measures and implementing them. This includes providing information about and assistance with BMP funding, which has become increasingly available as a result of Virginia's Tributary Strategies process.

Ensure continued maintenance of BMPs.
Where the BMPs require on-going maintenance in order to function properly, such maintenance should be ensured by the County through maintenance agreements with the owner. Such agreements are consistent with a requirement in the state Erosion and Sediment Control Program concerning maintenance of stormwater management structures. Maintenance agreements with commercial, industrial, and industrial property owners are fairly straightforward and easily enforced. Conversely, the County must exercise caution in accepting agreements that assign ultimate maintenance responsibility to homeowner organizations. Statewide experience demonstrates that such organizations are often not capable of following through with these responsibilities, such that local governments are often asked to assume the long term maintenance of the facilities.

3.5.2 Encourage Water Conservation Practices

Conservation practices can benefit both surface water and groundwater supplies. If less is withdrawn from surface water supplies, riverine habitat will not be as stressed during dry periods. If less is withdrawn from groundwater supplies, the chance of depleting the aquifer because water is withdrawn faster than the aquifer can recharge is reduced. Many conservation practices, and educational materials on them, are available.

3.5.3 Citizen Involvement

The importance of an educated citizenry in any pollution prevention programs can't be understated. Citizen involvement should be sought in developing the plans outlined in this chapter as well as to be educated and educate. The Fluvanna County Extension Service is well-suited to partnering with the County in educating citizens about the benefits of protecting the water supplies in Fluvanna County. The Rivanna River Basin Roundtable and the Rivanna Conservation Society are two groups which include concerned, active citizens who have already been working, and will continue to work, for the health of the Rivanna.